



Investigating Approaches to Achieve Modularity Benefits in the Acquisition Ecosystem

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EXECUTIVE SUMMARY

Our work in RT-163 was motivated by means by which the DoD can develop systems to exploit modularity to enhance defense acquisitions and military capabilities. The work centered on exploring the status quo on current practices in modularity and openness and explored the concept of a “MOSA ecosystem” that facilitates the adoption of strategies to achieve the desired benefits from a MOSA approach. The work investigated how to encourage modularity and openness, through researching relevant enablers across a range of areas of application.

Our team adopted a multi-pronged “knowledge acquisition” approach to achieve our research objectives, involving 1) a deep dive literature review, 2) conducting detailed collaborative exchanges with key subject matter experts, and 3) hosting a workshop with attendees from academia, industry and government. Our work results in a preliminary guidance document that contains useful artifacts for program managers and acquisitions practitioners related to achieving the benefits of modularity and in context of the ‘ecosystem’. We have further documented a portion of our work in the form of a draft journal publication processing through the final stages at the time of this report.

BACKGROUND AND RESEARCH OBJECTIVES

The DoD is challenged to affordably address emerging threats, component obsolescence, and loss of critical suppliers, and planned technology insertion/upgrades for tightly coupled, highly integrated systems, while increasing competition. Some of this strategy is articulated in its call for incorporation of modular design features in new DoD system designs. Standardized, documented modular interfaces enable “plug-and-play” insertion of upgraded or new capabilities on existing platforms, which can enhance innovation, increase competition; promote cost savings/cost avoidance; allow technology refresh, and achieve interoperability. Unfortunately, current standards are woefully limited in supporting the definition of modular interfaces in complex military systems. DoD needs a better understanding of the benefits and enablers of modularity in defense systems, in an acquisition environment with a diverse set of stakeholders, with sometimes with conflicting priorities, acting at various scales of resolution, such as making design decisions or establishing acquisition strategies, workforce initiatives or acquisition policies. It is believed that there is a fundamental set of objectives to encapsulate these needs, which may drive specificity of elements to support addressing the DoD challenges.

The ODASD/SE Modular Open Systems Approach (MOSA) initiative seeks to balance the business objectives (open systems support) with the technical means to meet the challenges, some of which are outlined above. To date, most work has been under the auspices of open systems architecture, or OSA. OSA has been primarily focused on the business side of the acquisition process, dealing with issues such as data rights and legal matters that are necessary, but not sufficient to achieve the objectives. The “Modularity Piece” needs to bring these technical trades to the fore to accompany OSA and the overall desire to provide a dominant warfighting capability for the nation’s defense.

RESEARCH NEEDED

This research investigated how DoD can develop systems to exploit modularity to enhance their effectiveness, as well as to work more effectively with other systems (in a system-of-systems context) in a variety of missions. The work also seeks to identify elements of the acquisition enterprise, or “ecosystem” that promote the development of these types of modular systems.

The research explored both the concept of an ecosystem (and whether or not it improves the opportunity for inhabitants of the ecosystem to use modular systems design) and strategies with or without this concept to obtain appropriate modularity and openness, depending on the desired objective. The first priority was to determine how to encourage modularity. The researchers were posed with questions such as how to choose boundaries in systems design that define modules (and thus define the interfaces in such a way as to minimize integration complexity).

The objective of this research was to investigate whether the nature of the particular ecosystem determines (or at least influences) what style and level of modularity should be employed, and

which functions naturally lend themselves to modularity. Some additional questions that guided the research include:

- Ecosystem concept: Based on a thorough literature review, what might be the “minimum equipment list” the DoD needs in order to support an ecosystem emphasizing modularity?
- How to articulate the relationship between modularity and openness, and what are some current examples both inside and out of the defense domain?
- Are there design patterns or characteristics in designs that enable modularity?
- Are there specific systems architectural decompositions (functional, physical, etc.) that best lend themselves to modularity?
- What factors enable a robust acquisition ecosystem to evolve over time, enabling the Department to achieve its innovation, competition, cost, technology and interoperability objectives?

SUMMARY OF RT-163 ACHIEVEMENTS

Our research in this RT-163 task successfully addressed the research need using the multi-pronged knowledge acquisition approach to maximize information gained to address the research objectives of this work. Given the size, scope, and exploratory nature of the research, the effort primarily executed:

1. Phase A: A deep dive literature review phase that explored case studies that document the effective use of modularity in system design for some or all of innovation, competition, cost, technology and interoperability; and, theoretical models tested and used in practice. Emphasis was placed on the domains that involved systems that related to a definable/desired systems of systems, especially with respect to the challenge of designing architectures for interoperability.
2. Phase B: A collaborative exchange phase that involved a) hosting a MOSA workshop with key attendees from industry, academia and government, and b) collaborative meetings, calls and email exchanges conducted on an individual basis with key stakeholders from the workshop, and with subject matter experts.

We summarize work performed on each in the following subsections.

PHASE A: DEEP DIVE LITERATURE REVIEW

We performed a deep dive into relevant literature on the successful application of modularity and openness in the development of engineering systems; this included relevant examples of implementation and/or test of ecosystem concepts within and outside the defense systems acquisitions context. We performed a detailed background research on the Modular Open Systems Approach (MOSA) including its implications on the technical and business elements of

acquisitions. Our background research included a detailed canvassing of relevant modularity and openness artifacts including:

- *Categories/Types of Modularity* – includes various types of metrics of modularity used and how it helped government/private entities seek benefits or enhance system development for their organization, including digital relevant threads. Exemplars on design patterns/characteristics that facilitated modularity were explored here as well.
- *Advantages and Disadvantages of Modularity/Openness*-includes detailed expositions on (among others) advantages that modularity has on development cycles, economic benefits, competition, and accommodating future uncertainty.
- *Industry/Government exemplars of modular and open strategy adoption in terms of a robust acquisition strategy.*

Our work in this stage continued with distilling the relevant knowledge and insights gained from our deep dive into a preliminary roadmap to better MOSA adoption for DoD acquisition practitioners, including identification of strategic level enablers that could encourage appropriate level of modular adoption.

We encapsulated the knowledge gained from this deep dive in the form of a journal paper submission titled “Leveraging Modularity Research to Guide MOSA Implementation”, and it is currently in submission to a special edition of the *Journal of Defense Modeling and Simulation*. At the time of this report, the draft paper is under review by the sponsor review team and the Modular Open System Working Group (MOSWG).

PHASE B: MOSA WORKSHOP OUTCOMES AND FOCUSED INTERVIEWS

Our Phase B of research involved the execution of a MOSA workshop that was held in Washington D.C. By all accounts, the workshop was a success and had 31 highly-engaged attendees [13 Government, 6 industry, 12 academia]. A list of the attendees of the workshop were provided to the SERC and the main synthesized outcomes from the workshop were distributed to attendees and briefed at the SERC Sponsor Research Review in December 2016. The workshop involved 3 main breakout groups with discussions in parallel tracks on identical itinerary of topics. The workshop targeted the following activities:

Participants will:

- 1) *actively contribute to in-depth discussions on defining, quantifying and assessing modularity and openness within the MOSA ecosystem;*

2) generate a consensus on meta-level strategies, identify barriers and potentially useful incentives;

3) synthesize a key list of stakeholder needs and/or concerns across a MOSA ecosystem gamut;

4) map beneficial elements of modularization strategies to appropriate acquisition processes to encourage appropriate adoption.

Participants will also assist in developing a useful repository of case studies (government/industry), including anecdotal evidence and lessons learned in the implementation of modular strategies.

Outcomes of the workshop, only summarized here, included the following consensus viewpoints on modularity, openness and their relation to defense acquisitions:

- **Modularity should not be seen as an output** (it is hard to measure it, especially with a single number), **but as an input** – a way to choose functional architectures
 - Be sure to have our own “feedback” measure to inform our choices.
- **MOSA is a means to the end we care about, which is the 5 benefits**
 - Since multiple stakeholders are involved, we also need to keep cognizance of time scales, i.e. who gathers benefits and when.
 - 5 benefits are interoperability, competition, tech refresh, innovation, cost saving
 - To facilitate this effort, pick one of the benefits as primary (some of those are conflicting, for example innovation and cost saving).
- To show “**compliance**”, evaluate the degree to which programs show that their **approaches – both on the technical and the managerial side – were good in terms of the of the estimated** (and well-balanced) **benefits**.
- Essentially, “**good modularity**” is same as **good architecting**; however, in this context **the complex ecosystem in which doing good architecting** (or good modularization) **is harder**
 - we need to **encourage greater intentionality** in appropriate style and amount of **modularization**.

Furthermore, attendees collectively recommended the following:

- Establish the **long-term business strategy, drivers and objectives for each stakeholder**, and their time horizons for MOSA-generated (or inspired) benefits
 - Keep into account polarities, e.g. data rights, competing interests (why would a program want to provide benefits to another program)
- **Tools to assess consequences of modularization choices**, under uncertainty
 - Holistic level tools (e.g. MBSE).
 - The consequences will be more visible on the data, for example on the 5 benefits, but some consequences – positive and negative – will be in all of the elements of the ecosystem (data managers, configuration managers, providers).
- **Feedback mechanisms, to help stakeholders understand the consequence of their actions and that of others**, and how the assessments are affected by their actions.
- **Case study approach** based on best practices, tacit knowledge, anecdotes.
 - Map these to appropriate parts of the overall acquisition lifecycle, in order to **develop “principles”** with case studies tagged.
- **Ask programs to start submitting “evidence”** (e.g. an analysis, an experiment) for their assessment of whether they are achieving benefits of good MOSA.

SUMMARY AND FUTURE PLAN

RT-163 has established a firm foundational understanding of the status quo on modularity and openness, and distilled SME knowledge on the ‘MOSA ecosystem’ construct and its potential use for encouraging/enabling appropriate widespread adoption of MOSA strategies in defense acquisitions. A key point found is that there is an emphasis on needing to view adoption of modularity and/or openness in terms of its desired benefits, as opposed to purely seeking ‘x% modularity’ for implementation sake. Our research has identified key implementation challenges, MOSA ecosystem enablers, case study-derived exemplars, and items requiring further research on identifying additional enablers and useful knowledge constructs. All of these are couched in practical terms in the form an initial Guidance Document for Program Managers that is also produced by the RT-163 effort.

The momentum in understanding MOSA started in RT-163 is proposed for continued work under RT-185 task titled ‘Approached to Achieve Benefits of Modularity in Defense Acquisitions’. The work will build upon, and, continue developing the knowledge base from this RT-163 task. In particular, the proposed RT-185 task will pursue a model-driven tool to guide practitioners in making more effective individual and collective decisions related to modularity and openness.